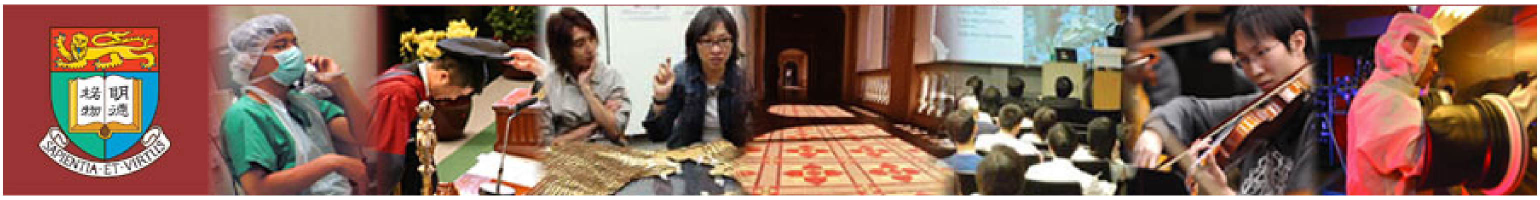

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Miniature Transparent UWB Antenna with Tunable Notch for Green Wireless Applications

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ABSTRACT: In this paper, the design of a UWB antenna using a transparent AgHT-8 material is proposed for green wireless applications. Computer simulation is used for studies. For verification of the design, the proposed antenna is fabricated on an AgHT-8 film and measured. Results show that the antenna has better radiation efficiency relative to its size than the previous designs, good omni-directional radiation patterns throughout the FCC bandwidth of 3.1 – 10.6 GHz and a comparable gain. To filter out the unwanted signals in the WLAN band, two vertical slots are introduced to produce a tuning notch in the 5 GHz frequency band. For demonstration of green wireless applications, the transparent antenna is incorporated with a solar panel for harnessing solar energy. Results show that the transparency of the antenna makes it a good candidate for future green wireless applications.

INTRODUCTION

In recent years, works on transparent antennas have been attracting attention [1-2]. However, other than the few papers that have been published, there are not many papers surfaced. The main problems of using transparent materials for antennas are 1) lossy nature of the transparent materials, 2) low efficiency and 3) difficulty in fabricating the designs. One earlier work on a transparent monopole antenna using the AgHT-4 material showed efficiency improvement with a trade-off in transparency for the material [1]. However, with the use of the same material AgHT-8 but with a higher surface resistance, yet maintaining full transparency, a much more recent work on a coplanar waveguide (CPW) ultra wideband (UWB) antenna showed that a further 20% improvement in efficiency could be obtained by using a novel soldering technique [2]. One of the factors affecting the efficiencies of AgHT-8 material is the surface resistivity which is inversely proportional to conductivity. The surface resistivity is noticed to increase and hence reduce the conductivity as the size of the antenna is miniaturized causing radiation losses. These losses are additional to the usual losses in the connectors due to soldering and impedance mismatching. In this paper, the design of a miniature transparent UWB antenna using the AgHT-8 material is proposed and presented. Results show that it has a slightly less efficiency than the one proposed in [2]. However, it has very good nearly omni-directional radiation pattern throughout the entire FCC UWB band of 3.1 GHz to 10.6 GHz. The antenna also demonstrates a very wide bandwidth and comparable peak gain.

To produce a tuning notch to filter out the unwanted signal in the WLAN band, two vertical slots are introduced as proposed in [3] to filter out the 5 GHz frequency band, avoiding interfering with the existing 5 GHz WLAN applications.

The miniature, slim and transparent features of the proposed transparent antenna allow it to be integrated with a mini solar panel or cell for harnessing solar energy. This can be used to provide backup and complimentary power for efficient use of the batteries in the UWB compact and slim devices. In this paper, this idea is demonstrated using a mini solar panel attached to a digital display. Such solar powered transparent antennas make them a good candidate for the green wireless technology of the future.

ANTENNA DESIGN

The miniature UWB antenna is designed using a transparent material, AgHT-8 as shown in Fig. 1. The rectangular radiator, the 50-Ω CPW feed and the ground plane of the antenna are all designed on a AgHT-8 film which has a thickness of 0.175mm and a surface resistance of 8 Ω-Sq equivalent to a conductivity (σ) of 1.25 x 10^5 S/m [1]. The

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AgHT-8 film is made of a transparent silver layer sandwiched by two layers of tin oxide on a thin polyethylene terephthalate (PET) substrate with a relative permittivity of 3.24. The dimensions of the antenna are designed and optimized using the EM simulation tool, CST Studio. The main rectangular part of the antenna serves as an upright radiator which has bevels at the bottom end and is fed by a 50-Ω CPW line as shown in Fig. 2. The bevel angle is very critical for impedance matching and so is optimized to give the best impedance matching [4]. The bevel edges and the top ground-plane edges together basically act as capacitors. Varying the capacitance helps improve the impedance matching and thus reducing the reflection coefficient of the antenna. The chamfers can also be used to further improve the bandwidth by increasing the reflection coefficient to more than 10 dB. All these result in a miniature transparent antenna with an ultra wide frequency band. In [3], a slot along the vertical edge of the radiator was introduced to produce a tuneable notch to filter out the possibly unwanted signal within the operation frequency band. Increasing the length of the slot would produce a notch at the lower frequency range, while decreasing the length of the slot would produce a notch at the higher frequency range. Here, we use two 0.3 mm vertical slots, each at a distance of 1 mm from the vertical edges of the rectangular radiator, as shown in Fig. 2, to produce a tuneable notch for the purpose of filtering out the unwanted signals.

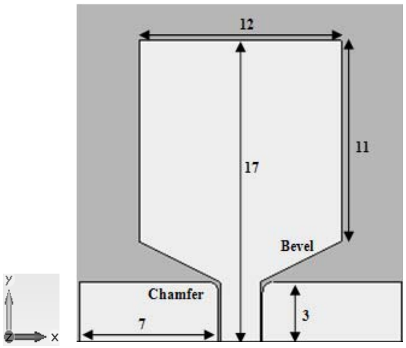


Fig. 1 Layout of transparent UWB antenna.

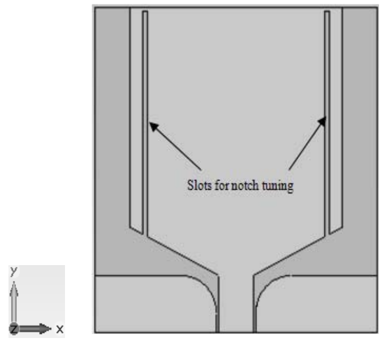


Fig. 2 Layout of transparent UWB antenna with slots for notch tuning.

MEASUREMENT AND SIMULATION RESULTS

The transparent UWB antennas, with and without the slots for notch tuning, have been designed and optimised using the EM simulation tool, CST Microwave Studio. To verify the design, the two antennas have also been fabricated on the actual AgHT-8 films. Fig. 3 shows the prototype UWB antenna without slots for the notch tuning. The antennas have been measured using the Satimo antenna measurement equipment, Starlab. The simulated and measured reflection coefficients without the slots are shown in Fig. 4 which indicates that the measured reflection coefficient is larger than that of the simulated reflection coefficient. The measured reflection coefficient is larger than 10 dB from 3 GHz onwards. With the slots for notch tuning, the return reflection coefficient is shown in Fig. 5, indicating that a notch is created at the frequency of 5 GHz. The variation in results between the simulated and measured reflection coefficients in both Figs. 4 and 5, could be mainly attributed to fabrication accuracy.

Fig. 3 Prototype-transparent UWB Antenna without slots for notch tuning.

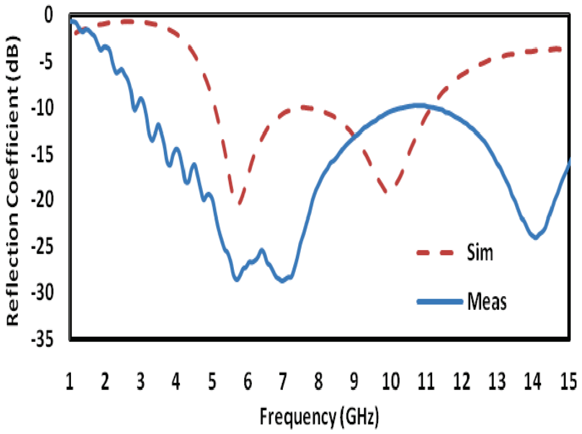


Fig. 4 Simulated and measured reflection coefficients of the antenna without slots for notch tuning.

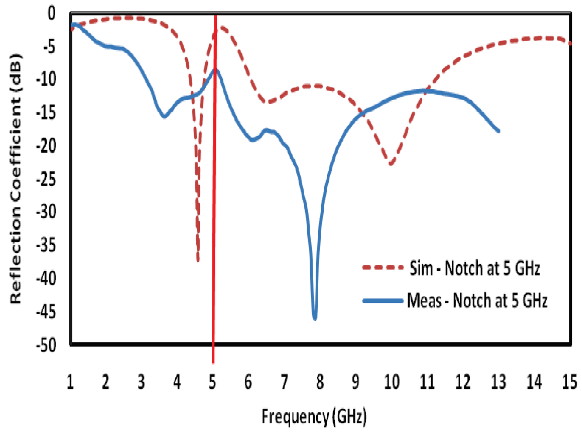


Fig. 5 Simulated and measured reflection coefficients of the antenna with slots for notch tuning tuned at 5 GHz.

The efficiency, peak gain and radiation patterns of the prototype antenna without slots for notch tuning have also been measured using the Starlab. The measured peak gain and efficiency of the antenna are shown in Figs. 6 and 7, respectively. It can be seen that the maximum peak gain is about -2 dBi at around 15 GHz and ranging from -6 dBi to -4.5 dBi within the UWB band assigned by the FCC. The maximum efficiency is about 18% at around 7.5 GHz. The low values of peak gain and efficiency obtained are expected considering the high loss of the AgHT-8 material. The measured 3-D radiation patterns of the antenna at different frequencies are shown in Fig. 8. It has very good omni-directional patterns at the frequencies of 3, 5, 7 and 9 GHz, making the antenna suitable for receiving signals from all directions throughout the FCC stipulated UWB bandwidth of 3.1-10.6 GHz.

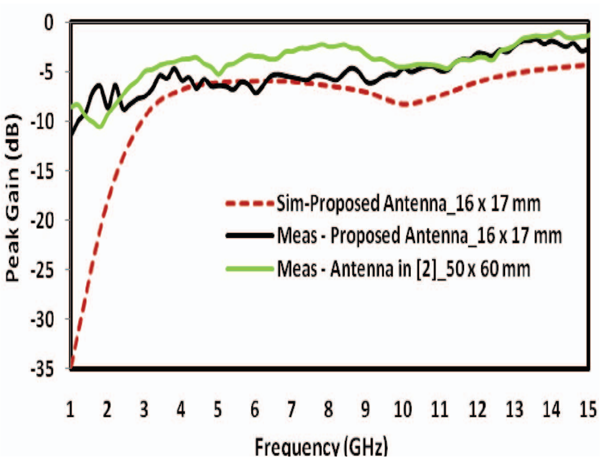


Fig. 6 Measured peak gain

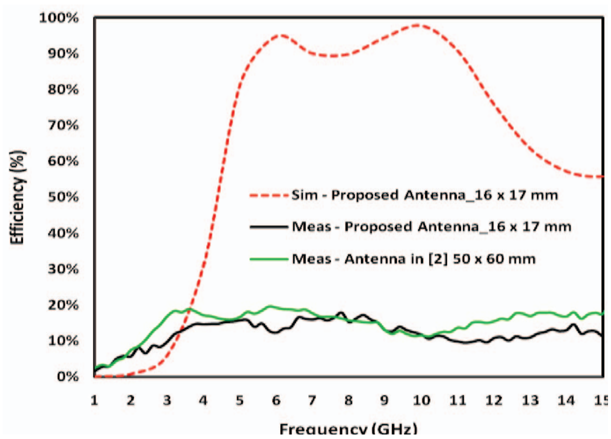
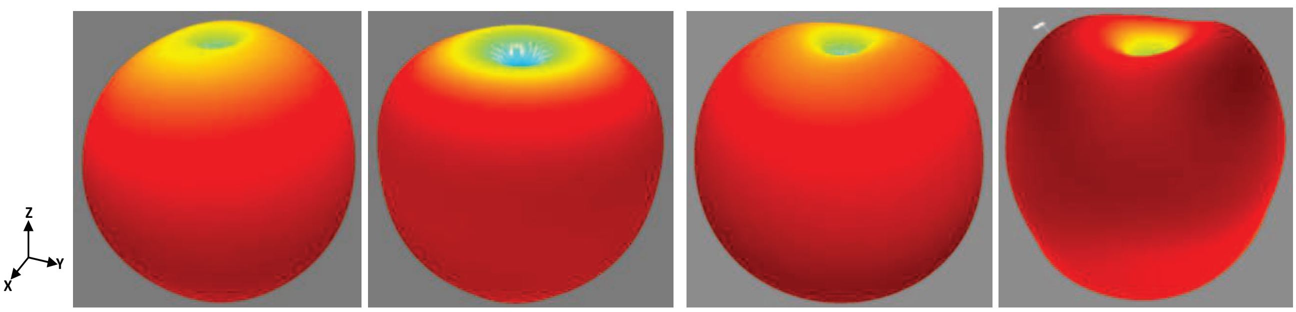


Fig. 7 Measured efficiency



a) b) c) d)

Fig. 8 Measured 3-D radiation patterns of antenna: a) 3 GHz, b) 5 GHz, c) 7 GHz and d) 9 GHz

INTEGRATION OF SOLAR PANEL

To demonstrate the use of the antenna for green wireless applications, we integrated a miniature solar panel to the back of the transparent UWB antenna. This enabled the solar rays to be harnessed through the transparent surface of the antenna to produce solar energy. This arrangement could be used to provide back-up power to complement the batteries used in the UWB devices. Fig. 9 further illustrates this arrangement. A digital display was powered on to display a 'zero' when the light from the room's lighting fell onto the mini solar panel from TRONY Solar (Model: 1025I) through the surface of the antenna. The digital display slowly powered off and the 'zero' display went off when the solar panel was obstructed or blocked from the room's lighting. This solar panel also could work in dim lighting and hence make the integrated antenna suitable for indoor wireless applications. This result shows that the transparency of the antenna makes it a good candidate for green wireless applications. Increasing the size of the antenna may increase the efficiency. Thus it is quite possible that we can use a larger solar panel for harvesting a greater amount of energy for various wireless applications and in different environments. Research on this is still ongoing and results are expected to be published in later publications.

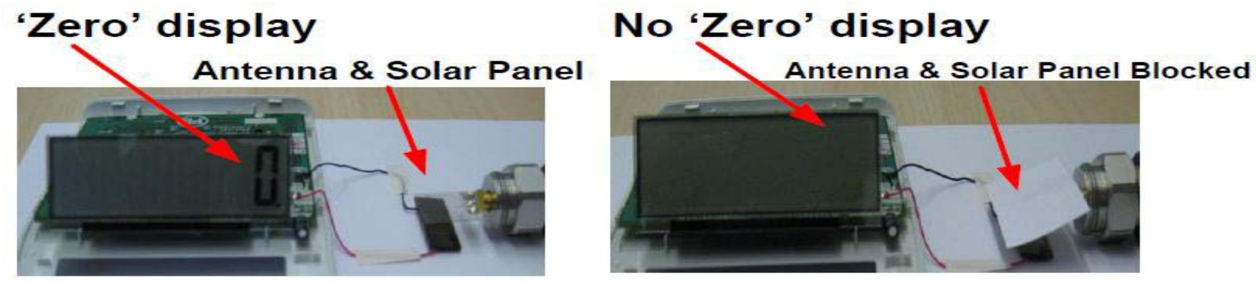


Fig. 9 a) Digital display powered on when solar panel is not blocked to display a 'zero'. b) Digital display being powered off when the solar panel is blocked and 'zero' disappears.

CONCLUSIONS

The design of a miniature transparent UWB antenna with a tunable notch for green wireless applications using an AgHT-8 film has been presented. The antenna has been studied using computer simulation, fabricated and measured. Results have shown that the antenna has a reasonable radiation efficiency, good omni-directional patterns and comparable gain. It has also been demonstrated that the transparency of the antenna makes it a good candidate for green wireless applications.

ACKNOWLEDGEMENTS

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REFERENCES

[1] H. J. Song; T. Y. Hsu; D.F. Sievenpiper; H. P. Hsu; J. Schaffner; E. Yasan, "A Method for Improving the Efficiency of Transparent Film Antennas," *Antennas and Wireless Propagation Letters, IEEE* , vol.7, pp.753-756, 2008.

[2] T. Peter; R. Nilavalan; H.F. Abu Tarboush; S.W. Cheung, "A Novel Technique and Soldering Method To Improve Performance of Transparent Polymer Antennas," Antennas and Wireless Propagation Letters, IEEE, vol.9, pp. 918-921, 2010.

[3] S. W. Bae; H. K. Yoon; W. S. Kang; Y. J. Yoon; C.H. Lee, "A Flexible Monopole Antenna with Band-notch Function for UWB Systems", Proceedings of the Asia-Pacific Microwave Conference 2007.

[4] M. J. Ammann, "Control of the impedance bandwidth of wideband planar monopole antennas using a bevelling technique," *Microwave Optical Technology Letters,* vol.30 (4), pp. 229–232, 2001.